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pony; a pretty good proof of the powers of endurance of those animals in this country.

No observations of any sort were made during my journey, for fear of giving offence to the Japanese authorities, who are to be found in every little hamlet, and whose conduct, together with that of villagers, was always most friendly.

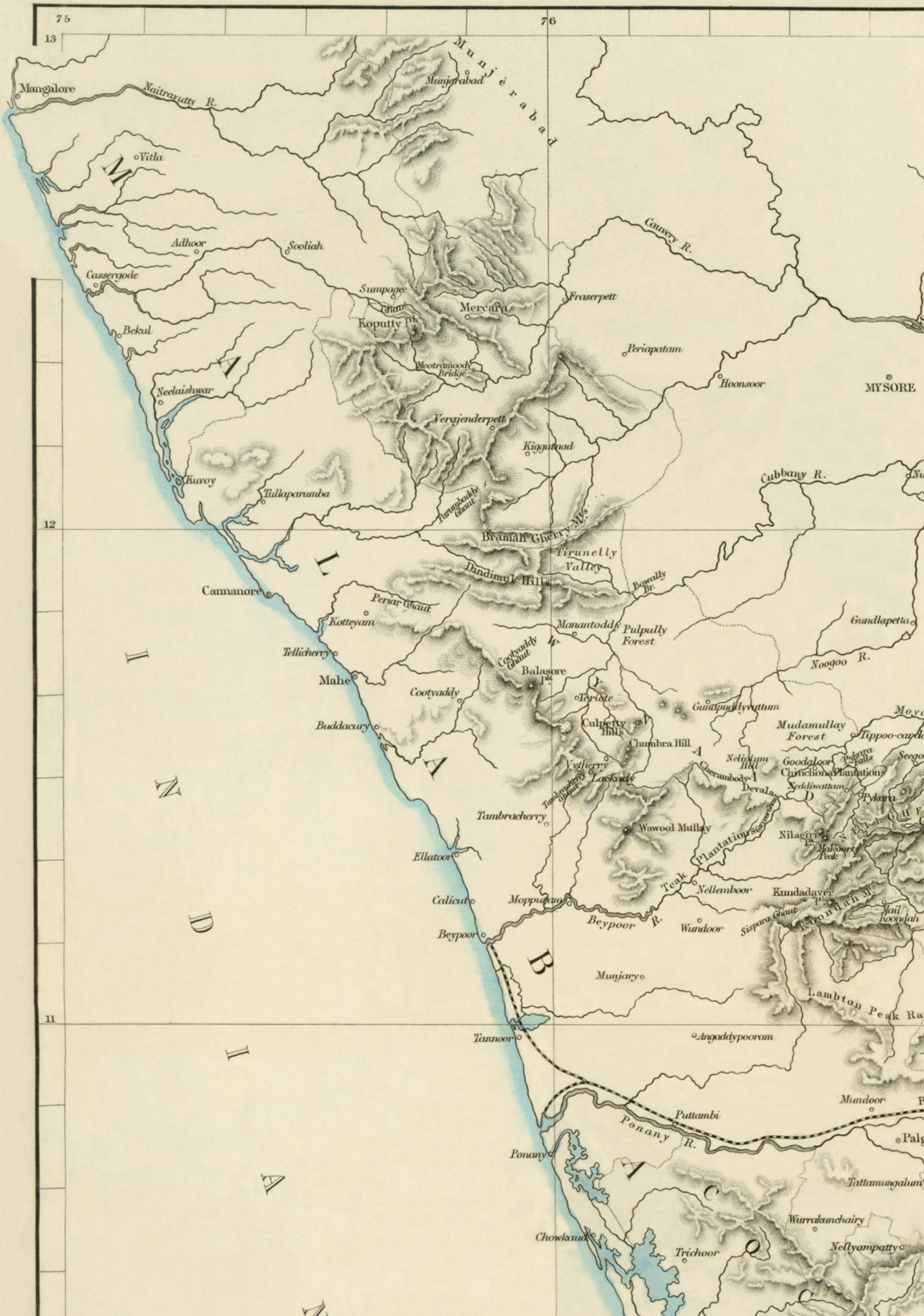
XI.—*On the Effects of the Destruction of Forests in the Western Ghauts of India on the Water-Supply.* By C. R. MARKHAM, Esq., F.S.A., Secretary R.G.S.

Read, June 11, 1866.

HUMAN action has produced great changes in the physical condition of the earth's surface. Vast tracts of swampy wilderness have been converted into fresh pastures or cultivated fields, and barren uplands have been covered with stately trees. On the other hand, many regions, in all parts of the world, which were once clothed with verdure are now treeless and arid wastes. All these changes are the work of man; some took place centuries ago, others are going on now, under the eyes of this generation. The destruction of forests has been one of the chief agents in effecting changes in the earth's surface, and the best methods of counteracting evils which may be caused by these extensive clearances is one of the most important questions that occupy the attention of physical geographers.

This agency is now at work in the Western Ghauts of India, those rich and beautiful mountain-districts forming the backbone of the Indian peninsula, and containing the sources of a water-supply, on which the prosperity—indeed, the very existence—of millions depends. The Western Ghauts of southern India, or rather that portion of them to which I now allude, extend for nearly 300 miles from Nuggur, in Mysore, to within a few miles of Cape Comorin, and have an area consisting of forest-covered slopes, grassy plateaux, and rocky peaks and ranges, covering somewhere about 7000 square miles.

The most northern part of the range is comprised in the two Mysore districts of Nuggur and Munjerabad, in the former of which are the sources of the Toongabudra; while the latter sends its waters to the Cauvery. Then comes the lovely little mountain-district of Coorg, containing the fountains of the sacred river Cauvery itself. Coorg is divided from the Wynaad district by the Bramah-gherry Mountains, and Wynaad extends for a length of about 50 miles to the feet of the Neilgherries, which rise up from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Fraserpett
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Gauvery R.
Periapatam
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MYSORE
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Parambaddy Ghaut
Bramah Gherry Ms.
Tirunelly Valley
Dindimul Hills
Bowally Br.
Cannanore
Periar Ghaut
Kotteyam
Manantoddy
Pulpully Forest
Gundlapetta
Tellicherry
Noogoo R.
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WYNAAD
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Culpetty Hills
Mudamullay Forest
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Moya
Chumbra Hill
Nelidlum Hill
Goodaloor
Pykara Falls
Seego
Chinchona Plantations
Vytherry
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Teak Plantations
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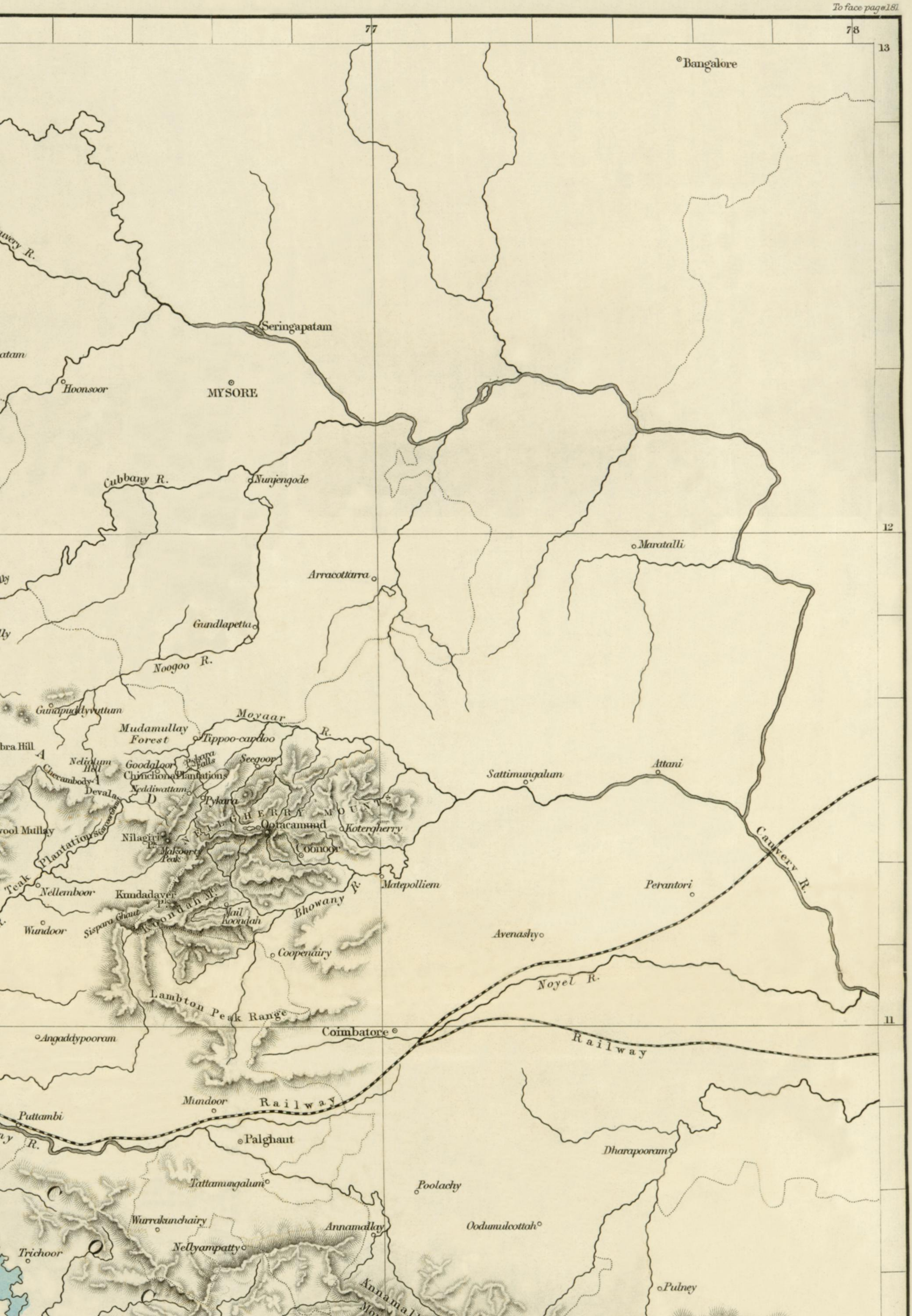
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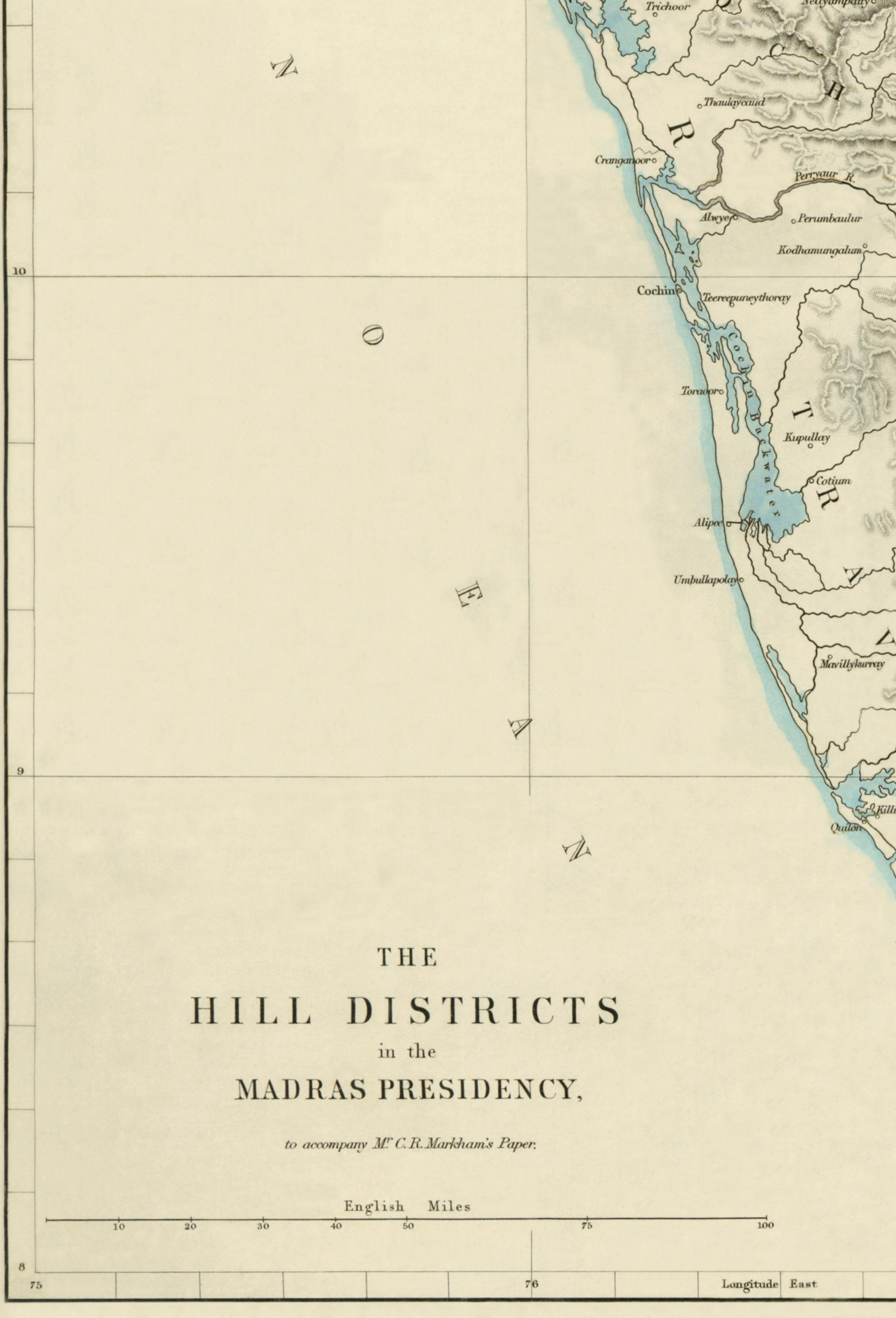
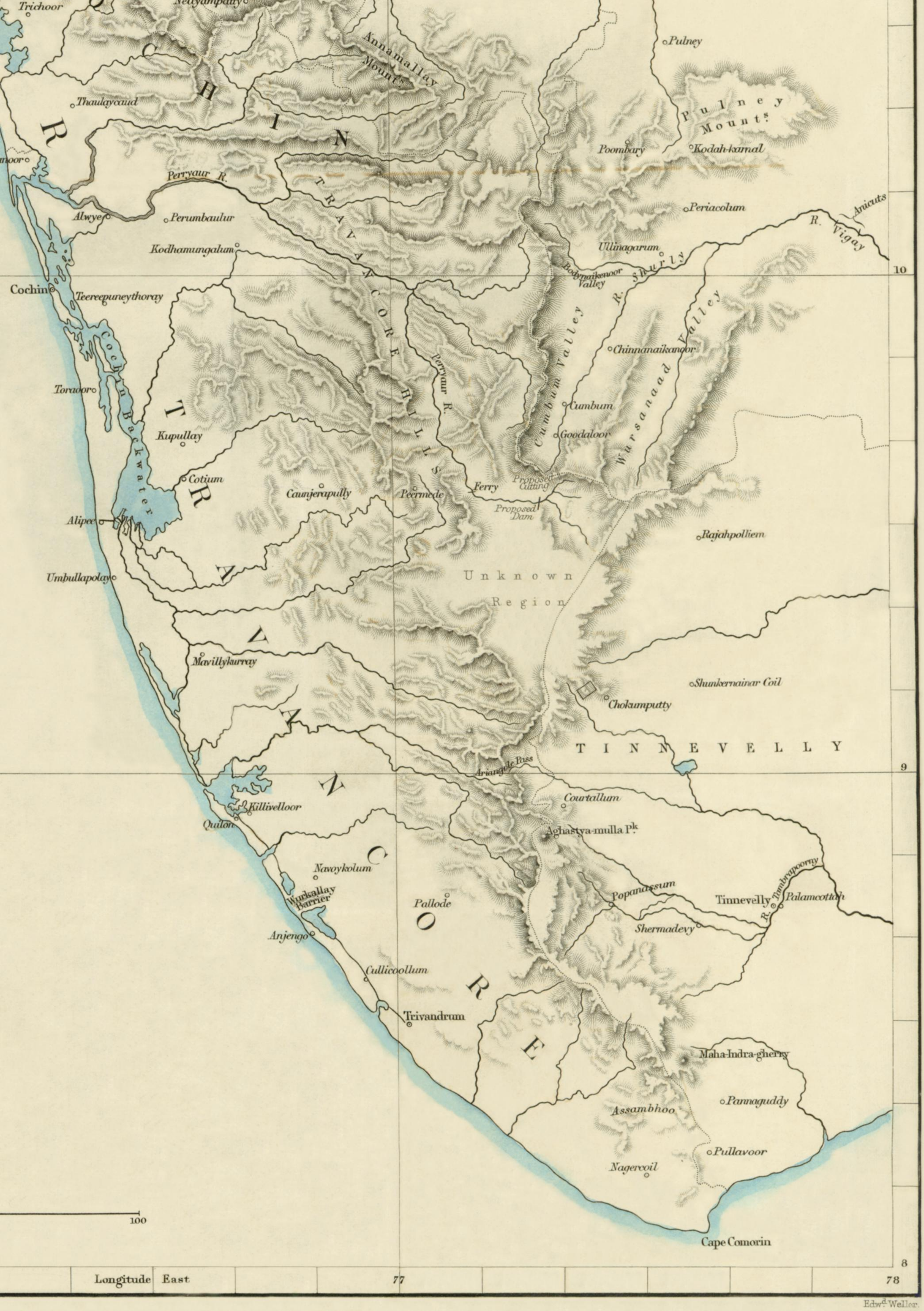


THE
HILL DISTRICTS
in the
MADRAS PRESIDENCY,

to accompany Mr. C. R. Markham's Paper.

Published for the Journal of the Royal Geographical Society by J.Murray,Albem



the Journal of the Royal Geographical Society by J. Murray, Albemarle Street, London 1866.

Edwd. Weller.

the Wynaad plateau like a massive wall, with many silvery cascades pouring over its face. On the western, or Malabar side, the mountains of Coorg and Wynaad rise abruptly from the plain, and are covered with magnificent forest. The plateaux are broken into a succession of ridges, sometimes rising into lofty peaks, which enclose valleys or flats—usually one mass of rice-cultivation; and on the eastern side the descent is more gradual, and is covered with forest.

The taluq or district of Wynaad is a plateau, averaging an elevation of 3000 feet above the sea, in the direct line of the Western Ghauts, between the mountain-knot of the Neilgherries on one side, and that of Coorg on the other. It is about 60 miles long, by 30 broad, and contains an area of some 725,000 acres. On the Malabar side, the upper half of the mountains consist of a succession of stupendous mural precipices, broken here and there by ravines and spurs, and wherever there is a foot-hold the ground is covered with magnificent forest-trees, many of them yielding valuable timber. On this western side there are several mountain masses which rise from the plateau to a height of 5500, and even 6000 feet, their sides clothed with forest, and terminating in well-defined peaks. One of these, the Velery-mullah, extends far out into Malabar. The others are the Chumbra, the Culpetty, the Koocha-mulla, and the Balasore hills. Their northern aspects are well adapted for chinchona cultivation, while their southern slopes, receiving the full force of the south-west monsoon, are less favourable to vegetation. Their rainfall is about 160 inches annually. The scenery of this western part of Wynaad is exceedingly beautiful, consisting of precipices of gneiss, rising out of forests clothed in many varied tints, rapid torrents and waterfalls, and wide views of the low country. From the western mountains the land slopes gradually down to the Mysore frontier, in a succession of ridges or low ranges of hills, intersected by swamps or flats, which, when left to nature, are overgrown with *pandanus*, but which are now for the most part covered with paddy cultivation. The ridges and hills consist of long stretches of grass-land, dotted over with clumps of bamboos, mango-trees with wide-spreading branches, and flowering shrubs, such as *Solanum Indicum*, a *Crotalaria*, a *Lobelia*, called by the planters wild tobacco, and an *Osbeckia* with a very pale purple flower. The leafless but bright-flowered *Erythrina*, and the wooden-fruited *Bignonia xylocarpa*, are also common. If the bamboos were absent, the central part of Wynaad would look like a beautiful but neglected English park. Occasionally isolated masses of gneiss rise from the plateau, some, like the hills of Nelialum, ending in needle-like peaks, others forming craggy precipices. These are the Nelialum Hills and Cheramcottah in south-east Wynaad, Cunjithcottah, Yeddacul near Sultan's battery, the Meenangaddy rock, Jiganabettah near Culpetty, and the "Central Hill" of Wynaad. All these are conspicuous landmarks. The eastern side of Wynaad up to the Mysore frontier consists of a belt of dense forest, here and there intersected by paddy flats (and we call these low swampy valleys on each side of a stream *paddy flats*, whether they are actually cultivated or not) for a width of 15 to 20 miles. The climate is here much drier than on the western side, and the trees, consisting chiefly of the deciduous teak, are stunted and undersized. There are extensive fires in the dry weather, when the traveller may ride for miles through a hideously desolate forest of trees with charred and blackened stems and leafless branches. The bright little *Indigofera pulchella* by the road-side alone relieves the dreariness of the scene. The Mudamullay forest, on the south-east side of this part of Wynaad, is worked by the Government for its teak and sandal-wood, being rented for 99 years from the Nelemboor Terupad, whose claim to it was very questionable, for Rs. 3500 a year. The rest of the forest near the Mysore frontier belongs to Government, with the exception of a large block, the claim to which by the Pulpully devasum has been allowed. The managers of the pagoda declare that their god does not allow it to be touched, and they will come to no terms with the Government with regard to the timber. The claim of the Tirunelly pagoda to another block of forest has been disallowed.

The drainage of the Wynaad district, excepting the torrents which dash down the western mountains during the south-west monsoon, is entirely to the eastward; the numerous streams uniting to form three rivers, which are tributaries of the Cauvery. The Moyaar drains South-east Wynaad and part of the Neilgherries, the Noogoo drains South, and the Cubbany North Wynaad. All the streams are fordable in the dry season, though the banks are often steep; but during the monsoon they swell to an immense size, often rising 30 feet, with a width of 200 feet, and dashing furiously along with masses of tangled branches and uprooted trees.

Coffee planting commenced in Wynaad in about 1840. Now there are 192 coffee estates, of which 9865 acres belong to Europeans, and 4748 to natives, actually planted.

South of Wynaad the great mountain-mass of the Neilgherries and Koondahs rises to a much higher elevation, the plateau being 7000 feet, and the highest peak 8829 feet above the sea. The area of the Neilgherries contains 268,494 acres. The formation, like that of Wynaad and Coorg, consists of syenitic granite, with veins of basaltic rock, hornblende, and quartz, while in some parts half-decomposed laterite underlies the soil. The plateau of the Neilgherries is not a flat table-land, but consists of a succession of undulating hills and intervening grassy valleys, with ravines thickly wooded, numerous streams, and occasional rocky ridges running up into fine mountain peaks. The streams all go to swell the great river Cauvery by its tributaries the Moyaar and Bowany; the Moyaar descending from the hills by a grand waterfall in the Pykara chinchona-plantation on the northern slope; and the Bowany flowing down between the Koondahs and Neilgherries to the south. The soil of the plateau is very rich, being formed by the decomposition of basaltic and hornblende rocks, mixed with clayey products of the granite and decomposed vegetable matter. There are extensive deposits of peat in the valleys, which afford supplies of fuel. The chief defect in the soil is the absence of lime. On the open plateau, in the wooded *sholahs*, and in the thick forests of the lower slopes, there is a great variety of beautiful flowering trees and shrubs. First in the brilliant splendour of its flowers must be mentioned the tree-rhododendron (*Rhododendron arboreum*), which is very common in all parts of the hills. In the wooded ravines are the *Michelia Nilagiraca*, a large tree with fragrant flowers of great size; the *Symplocos pulchra*, with hairy leaves and snow-white flowers; the *Ilex Wightiana*, a large umbrageous tree; the pretty pink-flowered *Rhodo-myrtus tomentella*, or hill gooseberry; the *Jasminum revolutum;* the *Sapota elingoides*, a fine forest-tree; *Crotalariæ*, *Bignoniæ*, and a number of chinchonaceous trees. On the open grassy slopes the most common shrubs are a *Lobelia*, a *Crotalaria*, a *Vaccinium*, a *Berberis*, and an *Osbeckia*, with a purple flower of a much darker shade than appears on the same shrub at the lower elevation of Wynaad.

South of the Neilgherries that remarkable gap in the ghauts occurs at Palghat, which enables the railroad to pass from sea to sea—from Madras to Beypoor. The eastern drainage from Coorg, Wynaad, and the Neilgherries is all to the Cauvery.

The mountains south of Palghat are thus completely isolated from the main range of the ghauts. They comprise the glorious Anamallays and Pulneys and the hills of Travancore, including vast forest-covered tracts as yet unexplored, and containing the sources of water-supply for Madura and Tinnevelly; and those of the great river Perryaur, which now pours its floods uselessly into the Cochin backwater.

The mountains from Palghat to Cape Comorin may be divided into two distinct regions for purposes of description, which are separated from each other by that extensive unknown tract of country, where the sources of the great river Perryaur are still concealed from our knowledge. The southern region extends from Cape Comorin to Courtallum, and comprises the mountain chain which divides Travancore from Tinnevelly. Near Cape

Comorin, isolated masses of weather-beaten rock rise abruptly from the plain, and form an outline of battlements and pinnacles against the sky; and the continuous range only commences north of the Aramboly Pass, where the mountains attain a height of 3000 feet and upwards. The range is not broad, and has little or no intermediate table-land, but slopes abruptly from the summit ridge to the rich green expanse of Travancore on one side, and to the dried-up plain of Tinnevelly on the other. The peaks rise to a height of 6000 feet. Several coffee estates have already been formed on these hills. The most southern are at Assambhoo, at an elevation of 3000 feet, immediately above the Aramboly Pass. The principal drawback to this site is its exposure to severe gales of wind, which do much injury to the plants. Further north, and on the Tinnevelly side, at the feet of those grand precipices called Maha-Indra-gherry and Tirana-mullay, there is a small coffee estate, owned by a wealthy and liberal-minded Mohammedan, named Meer Anjemir, who lives at Pannaguddy. At the foot of the peak of Aghastya-mullay, in Travancore, a fine tract of forest land has been purchased, and there are several coffee estates round Courtallum.

There is a notable difference between the climate on either side of these ghauts. On the west side the slopes are abundantly watered by the south-west monsoon, and the streams fall into the backwater, supplying the narrow strip of land with water in abundance. On these Travancore hills clearing may be carried on to any extent, without detriment to the low country, which could well dispense with some of its surplus moisture. But, on the east side, the due supply of water for the tanks and channels is a necessary of life to the people inhabiting the wide plains of Tinnevelly. Indiscriminate felling on these eastern slopes would lead to most deplorable results, and the evil is already beginning to be felt. Further grants of land have been prohibited in the Tenkassy Taluq, and in Nanganary the people complain bitterly of the drying-up of the streams. There can be no doubt that serious consequences will arise from indiscriminate felling; but, when Rs. 1,84,000 are required for the repair of tanks and channels in Tinnevelly, and only Rs. 48,000 are granted, the failure of water cannot be *entirely* due to a reduction in the rain-fall caused by clearing on the hills.

The northern division of the mountainous country extending from Palghat to Cape Comorin includes the Anamallay and Pulney hills in British territory, and an extensive hill district within the native states of Cochin and Travancore. It differs from the southern division in possessing several ridges with wide stretches of table-land, instead of a single line of mountains sloping directly from their summits to the plains on either side.

There is a very extensive mountain region between the plains of Travancore and those of Madura. The southern portion, extending over an area of about 30 miles by 20, out of which issues the river Perryaur, is entirely unknown and is a blank on the map. The northern part borders on the Anamallays, and is almost as little known. The great river Perryaur, flowing from south to north, traverses the centre of this mountain region, and, after a long course, eventually turns to the west and falls into the Cochin backwater. In December, 1865, I crossed this mountainous country on foot, with Dr. Cleghorn. Our route passed right over it, crossing the Perryaur. The mountains are owned, under the Travancore Government, by the petty Rajah of Pooniat, and from time immemorial there has been a track called the Pooniat Road, traversing Peermède and passing down into the Cumbun Valley on the Madura side. It was used by the elephant-hunters whose old pits are still to be seen, and by the Pooniat Rajah's cardamom gatherers. The ancient Pandyon kings of Madura are said to have received their supplies of betel, pepper, and cardamoms by this route, in exchange for rice and cloth. At present the Madura people annually drive their herds up to these mountains for pasturage, but the only inhabitants are a wild tribe of wandering hill people called Uralas. They are seldom seen.

The distance from Peermède on the western edge of the mountains, where there are several coffee estates, and a chinchona-plantation, to the Perryaur River is 7½ miles on the map, 10 miles by our route; from the Perryaur to the eastern crest of the ghauts, 5½ miles on the map, 8 miles by our route; from the crest of the ghauts to Goodaloor, on the Madura side, 8 miles on the map, 12 miles by our route. A total distance of 30 miles on foot, over a most difficult country.

The road leads from Peermède across grassy uplands, with much rock on the surface, to the river Urraday, and crosses the stream at the Urraday Tavalum. These *Tavalums* frequently occur on the map. They are merely places where herdsmen are in the habit of resting their bullocks, and are known by several acres being overgrown by a species of *Compositæ* (*Blumea*), the result of bullock manure. The land must be very rich and valuable. There are several magnificent *sholahs* on the hills overhanging the Urraday, and facing to the westward; but after crossing them the country to the eastward presents a hotter and drier appearance, the *sholahs* are smaller, there are large patches of *eetah* bamboo in them, indicative of a poor soil, and they often only extend a few yards on either side of the streams. We saw several bison on high hills to the south, samber bounded before us into the sholahs, and there were numerous traces of elephants and cheetahs. We passed through the *Pambanum* (snake) *Tavalum*, and over hills covered with grass 10 and 12 feet high, a most blinding and tedious march, and finally came by a steep descent, through bamboo jungle, to the banks of the Perryaur.

Although this was nearly the lowest season, the river was 30 yards across, and we found by the marks that, during the monsoon, it rises 8 feet higher. The whole of this immense volume of water now runs to waste in the Cochin backwater. But there has long been a project to build a dam across, at a point 13 miles south of where we crossed, and to make a cutting, so as to throw the river over into the Madura district.

The coffee plantations have already begun to attract traffic over this formerly unfrequented route, and before long, a good bullock-track, and a bridge over the Perryaur, will become an urgent requirement of the district. The rice and cloths of Madura will be exchanged for the silver of the planters and the betel, cardamoms, and tobacco of Travancore. We found 200 bullocks on the banks of the Perryaur, laden with rice for the coffee plantations, coming from the Cumbum Valley. The bullocks were driven in, and made to swim across, while the bags of rice were ferried over on a rude bamboo-raft; a process which seemed likely to occupy at least twenty-four hours. One only has to be a witness of proceedings such as this, to be deeply impressed with the delay and injury caused by the absence of bridges. We crossed the river on the same bamboo-raft, but the coolies with our tent did not arrive until late, having been driven or rather frightened off the road by a herd of wild elephants. The river is here lined on both sides with clumps of bamboo; the bed is very rocky, and the water clear and cool. As night closed in, the fires of the herdsmen and the mass of white bullocks under the bamboos were finely reflected in the river. Fires throughout the night were necessary, to keep off the tigers which abound in extraordinary numbers, denoting the great abundance of other kinds of game.

After passing up the bamboo-jungle which fringes the river on the east side, we entered upon a country presenting a still more dried-up appearance, though the grass was of immense height. Stunted trees were scattered over the open hills, chiefly *Terminalia coriacea*, and here we met with the first teak-trees. The land is formed into a large amphitheatre of hills, with two sharp peaks, and after descending the slopes, we entered a thick bamboo-jungle, and had to wade along the bed of a torrent up to our knees for a considerable distance. The woods abound in black monkeys with white beards, jungle fowl, and imperial pigeons. The Goodaloor Tavalum is an open space in the midst of the forest, about 5½ miles from the Perryaur, and close to the crest of the eastern side of the ghauts. The descent into the Cumbum Valley is rapid and precipitous, over huge boulders of rock, and often crossing a mountain torrent. The ghaut is clothed with splendid forest-trees. Black wood (*Dalbergia latifolia*), one of which I measured 4 feet from the ground, and found to be 17 feet in girth, and another was at least of equal size; *vengay* trees (*Pterocarpus marsupium*), yielding excellent wood for building purposes, as well as the gum *kino* of commerce; a tree called locally *vekali* (*Conocarpus latifolius*), the wood of which is also used for building; the black dammer-tree; and, lower down, great quantities of the loathsome *Sterculia fœtida*, which yields an inferior kind of poon spar. Here and there we got peeps of the rich Cumbum Valley as we descended, with mountains on the opposite side. On first coming out into the valley, there is a wide stretch of open grass-land dotted with the *yerkum* bush (*Calotropis gigantea*), where immense herds of cattle were feeding, and further on there are fields of castor oil, and fine crops of toor and raggee.

The Anamallays have been well described in Dr. Cleghorn's work, and an account of the Pulneys will be found in my 'Travels in Peru and India.'

It is scarcely necessary to say that the rainfall along these Western Ghauts is derived almost entirely from the south-west monsoon, and that consequently nearly the whole of it is deposited between the months of May and September. But it is worthy of note that the amount of rainfall along the ghauts decreases as Cape Comorin is approached. Thus at Mahabaleshwar, near Bombay, it is 248 inches, while at Trivanderum, the capital of Travancore, it is 65, and at Cape Comorin itself only 30 inches. The gradual narrowing of the peninsula will probably account for this phenomenon. The heaviest rainfall of course takes place along the western faces of the ghauts, where the clouds, heavily charged with the moisture from the Indian ocean, suddenly enter the colder stratum caused by the mountains, and are at once condensed. As they advance across the plateaux the amount of rain deposited by them sensibly decreases; and the rainfall, in special localities, is affected by the smallest variations of aspect and shelter. Thus the western forests of Nuggur, Coorg, Wynaad, and the Koondahs, receiving the full force of the monsoon, have a rainfall of about 200 inches, while at short distances to the eastward it is much less heavy. At Mercara, in the centre of Coorg, it is 145 inches, and at Nuggur about 100. The effect of aspect and variations of exposure on rainfall is well shown on two estates on the slopes of the Chumbra Hill, which rises out of the Wynaad plateau. On the one with a western aspect it is 186 inches, on the other, within a few miles, but sheltered by the peaks of the Chumbra Hill, it is only 154 inches. At the Nediwuttum chinchona-plantations on the Neilgherries, which are about 8 miles to the eastward of the line of mountains on which the monsoon rains first burst, the rainfall is 127 inches. At the Dodabetta station, the highest peak on the Neilgherries, the average annual rainfall from 1847 to to 1855 was 86·13 inches; the maximum annual rainfall being 102·83 in 1847, and the lowest 65·99 in 1848.

Although the rainfall thus varies, according to local circumstances, every particle of moisture is wrung out of the clouds in their passage from the Indian seas, by the intervention of the mountains. The forests which clothe their sides, and fill the valleys and ravines on their plateaux, have the effect of regulating the flow of water to the eastward, but I cannot see that their presence or absence would have any influence on the actual amount of rain which falls on the hills. The intervention of mountains 8000 feet high, and the consequent change of temperature, will always wring the moisture out of clouds coming from the Indian ocean.

Within the last twenty years a great change has come over the mountain districts of the Indian peninsula, a change which is still in progress. An English colony is establishing itself in them, one which is, as I cannot help believing, of great promise, and one which is founded on different principles from any that has hitherto emanated from the British race. It is not a colony of needy adventurers and of labouring men, formed on the principle of exterminating the aboriginal population, and seizing their land: such as has swarmed upon North America, Australia, and New Zealand. But it is a colony of planters who generally enter upon the occupation of hitherto waste land, either belonging to the State or to native owners, the latter receiving its full value in parting with it. The native population, instead of being exterminated, as is the case in all other English colonies, make their own terms as labourers and carriers; and the extensive settlement of Englishmen on these hills, by raising the price of labour, has been almost an unmixed benefit to the natives, not only of the immediate vicinity, but of distant districts in all directions, to which the influence of the labour market extends.

On the other hand, the settlement of planters on the hills has given rise to wide-spread destruction of the primeval forest. The planters are occupied chiefly in the cultivation of coffee, to which have been recently added tea, and the quinine-yielding chinchona of South America. These three products give rise to the felling and clearing of forests, in the formation of plantations. In Nuggur, Munjerabad, and Coorg, several thousand acres have been taken up; in Wynaad about 16,000; on the Neilgherries some 9000, besides the Government chinchona-plantations; in the Anamallays some 600 acres have already been cleared; at Neliampaty in Cochin about 1200; at Peermede in Travancore, 625; and on the hills overlooking the district of Tinnevelly some

500; making a total area of little short of 60,000 acres of forest destroyed. Nor has the process by any means reached its limit; and a great change is taking place in the physical condition of the hill-districts.

It is impossible to exaggerate the importance of ascertaining exactly the nature of the changes caused by these clearings, and the best means of obviating the evils that may arise from them; for on the nature of the water-supply from the hills depends the irrigation of a large part of the peninsula.

One obvious consequence of the destruction of forests is an increased rapidity of surface-drainage, giving rise to sudden and destructive floods at the outlet on the plains, where the change of slope causes a diminution of velocity, and to injurious freshes in the irrigating rivers after they have reached the plains. The effect of vegetation is undoubtedly to retard evaporation, and to check the rapidity of drainage; and the removal of forests of course has an opposite effect. The hill-districts of India are now affording proofs of this law of Nature. The floods caused by the monsoon rains are yearly increasing in size and violence. To give one or two out of many instances:—During last monsoon two floods swept down the gorge at Coonoor in the Neilgherries, doing much damage, and they were of a volume such as had never been known before. Again, the bridge of the Mootramuddy in Coorg was swept away by the floods of 1863. Plans were drawn up for a new bridge which should be out of reach of all future floods; but in the following year they rose to a greater height, and in 1865 higher still. All this is clearly due to the extensive clearance of forests, owing to which the rain-water rushes off the surface, instead of sinking into the earth and forming springs.

Major Sankey, in his interesting Report on the state of the roads in the Coorg district, has pointed out other injurious effects of indiscriminate felling on mountain-roads. The planters clear away the trees above these roads, and run horizontal drains to prevent the soil from being washed away from their coffee-plants. These drains become surcharged, burst at different points, and form perpendicular channels, at the end of each of which most formidable breaches are made in the roads. These breaches often occasion chasms in the roadway itself, and Major Sankey is of opinion that the original form of the hills may be permanently altered. The only remedy appears to be to preserve a broad fringe of trees and bushes above the road. Equally disastrous consequences arise from clearing below the roads which pass along a mountain-side. The water drains off the road; the planter below naturally cuts a longitudinal drain to prevent his soil from being washed away, which operates to undermine the bank, and causes frequent breaches. Major Sankey, therefore, strongly urges the necessity of preserving a belt of jungle both on the upper and lower slopes of all mountain-roads.

For the last twelve years, a system of forest conservancy has been established in the Madras Presidency, under the able and zealous superintendence of Dr. Cleghorn; with a view mainly to the preservation of valuable timber and of firewood, and to the retention of belts of forest near the sources and along the courses of streams. The construction of public works is by far the most important part of our mission in India, and their completion will form the chief, if not the only justification of our occupation of that vast empire. As a branch of the Public Works Department, a forest agency is very necessary, both for the supervision of selling and planting on a proper system, so as to ensure an adequate supply of timber for public works, and of fuel for railways; and for the conservancy of forests, to obviate the disastrous effects of indiscriminate felling on bridges, roadways, and irrigation works. The operations of this agency have been judiciously conducted, but it is not to be expected, nor even to be desired, on other grounds, that any government agency should hinder the very extensive embarkation of capital in such enterprises as chinchona, coffee, and tea cultivation. Teak, black wood, sandal-wood, vengay, and other trees yielding valuable timber, should be grown in large plantations near streams, by which they can be floated down to a market. These plantations must hereafter supply the demand for timber, and help to obviate the evils attending the destruction of the natural forests.

A noble commencement of such plantations has already been made at Nelemboor, in Malabar. The teak-plantations, for which India is indebted to the far-sighted wisdom of Mr. Conolly, commence nearly opposite Mombat, and extend for seven miles along the north, and for several miles along both sides of the Nelemboor River. The long vistas of tall and perfectly straight trees present a striking appearance. The stems are often without a branch for a height of 70 feet and upwards. Those planted in 1843 I found to be 5 feet 2 inches in girth, at a distance of 3 feet from the ground, and 90 feet high; those of 1847 were 3 feet 11 inches in girth, and 70 feet high. Several acres are planted every year, and the newest piece with the nursery, is now three miles beyond Nelemboor. The finest view of the plantations is from the bed of the river, where there is a foreground of drooping, feathery bamboos, above which the stately teak-trees appear with their large pale-green leaves, while the line of the Neilgherries, crowned by the needle-like peak of Makoorty, bounds the distant view. From 1844 to 1865 the number of teak seedlings planted was 1,678,679, covering 1696 acres; and in 1865 the receipts were 27,158*l.* against an expenditure of 16,026*l*. These valuable teak-plantations are under the able superintendence of Mr. Ferguson, an experienced Scotch forester; and no better measure could be adopted for the future management of the forest agency than to establish a sort of school of forestry under Mr. Ferguson at Nelemboor, where natives might be trained and instructed.

There are also teak and sandal-wood plantations in the Mudamullay forest in Wynaad; a very fine plantation of Australian trees near Coonoor, on the Neilgherries; and a commencement has been made in Nuggur of another teak-plantation. The introduction of plantations of cork-trees into India, where there is every reason to believe that they would thrive, both in the Punjab and Himalayan slopes, and on the Western Ghauts, would likewise materially lessen the mischief caused by indiscriminate felling, while another valuable product would be added to the list of Indian exports.

It must also be remembered that one of the three products, the cultivation of which is now extending so rapidly in the hill-districts, will have the effect, in a few years, of supplying the place and performing the functions of the original forest. The beautiful foliage of the chinchona-trees, which after four years of growth are 20 feet high, will be as effective as the trees they have supplanted in preventing evaporation, regulating drainage, and receiving the moisture which is wrung out of the passing clouds. For this reason, as well as because it will be more remunerative and safer than coffee, and can be carried on in a healthier climate, chinchona cultivation deserves the notice of planters; while the healing qualities of chinchona bark should induce the Government to encourage its cultivation round the native villages in the hills, by offering prizes, and by every other suitable means.

In the end of 1866 there were upwards of 1,500,000 chinchona-plants in the government plantations on the Neilgherry Hills, besides many others under cultivation by companies and private individuals. It is the intention of the Government to plant 1200 acres with chinchona-trees, and to keep another 1000 acres as a reserve for further planting, if it should be considered desirable hereafter. Many hundreds of acres will soon be planted in addition, both on the Neilgherries and Koondahs, and in Wynaad, by English capitalists, as well as by natives; and the chinchona on the hills, like the teak on the lower slopes and in the plains, will tend to mitigate the effects of extensive felling.

Still many square miles will be bare, which once presented an unbroken surface of foliage. The forests will, to a great extent, disappear, and it is necessary that some other agency should be found to perform their duties—which are those of regulating and economising the drainage of the rain-water.

In almost all countries there is either something to check the rapid flow of the rain-water in surface drainage, or else there are disastrous floods. This agency acts as a sponge. It consists either of a large area of forest, or of swamp, or of peat-bog, or of a system of lakes, or of artificial reservoirs. In Yorkshire the sponge was provided by the undrained moors of the North and West Ridings. As these moors are drained the safety-valve is removed, and the heavy floods of the autumn of 1866 are the immediate consequence. If the moors are completely drained, artificial reservoirs must eventually be substituted, or the floods will be a chronic and increasing evil. In France there is no sponge of any kind to regulate the waters of the Loire, and consequently there are frequent and disastrous floods; while on the Rhone the lake of Geneva performs that important duty, and hence the floods are less violent and not so frequent. The river Po and its numerous affluents are always completely under control, because, at the head waters of each river, there is an efficient sponge provided by the lakes at the foot of the Alps. The river Ebro, in Spain, has no such moderator, and destructive floods in the country round Tortosa are, therefore, frequent.

On the Western Ghauts the sponge is furnished by the extensive forests which clothe their sides, and when these are removed to any great extent, it is essential to the welfare of the whole peninsula of India that a system of storing water in large reservoirs or artificial lakes should be substituted. The subject has already received some attention, and Sir Arthur Cotton urged the necessity of forming reservoirs on the Neilgherries more than thirty years ago. Dr. Balfour has also written two valuable papers upon the subject. But nothing has been done, and we can, therefore, only glance over what has been proposed. And first as to the water-supply from the Nuggur and Baba Bodeen hills, which contain the sources of the Toongabuddra River. To this river the vast territory known as the Ceded Districts, as large as Ireland, and (if we except a few mangy babools) almost devoid of trees, looks for its future fertility. The Choardy, Toonga, Budra, and Huggry, are the affluents which form the Toongabuddra, and, if the means of raising two crops is ever to be furnished to the lands within reach of the projected irrigation works in the Ceded Districts, large reservoirs must be formed in the hills, on the upper courses of these streams. The most favourable sites are probably at the ancient tank of Mudduck Masoor on the Choardy, at Mudala on the Toonga, and at Luckawally on the Budra.

South of Nuggur, from Munjerabad to the Neilgherries, the whole of the streams rising in the hill-districts go to form the mighty Cauvery, a river on the waters of which depend the irrigation of a great part of Mysore, of that marvellously rich garden of Tanjore, and the projected conversion of the arid plains of Coimbatore into one sheet of cultivated land. Reservoirs have been proposed both in Coorg and Wynaad, and a very thorough examination of sites on the Bowany and Moyaar—the rivers that drain the Neilgherry and Koondah hills—was made in 1856 by Mr. Fraser, an engineer of the Madras Public Works Department. Detailed plans and estimates were then completed for a great reservoir on the Manal Kava. Another was proposed at a site about a mile below the junction of the Moyaar and Bowany rivers, where a bund might be thrown across a valley. The two rivers drain a catchment basin of 1600 square miles, the greater part of which is on the Neilgherry and Koondah hills. Another site for an artificial lake was suggested by Mr. Fraser, at a place called Palavur, on the Bowany River. Here a bund 852 yards long would form an artificial lake 45 miles round, with a capacity of 507,250,000 cubic yards of water; the whole area being now a wild and uninhabited jungle. Above Palavur there are several other good places for forming reservoirs on the Bowany; but on the Moyaar* there are no favourable sites, though comparatively small basins might easily be formed. Finally, on the Neilgherries, the streams flowing through Love Dale, and from Bishop's Down and Marjanaad, unite in an extensive flat, where a large reservoir might be formed. The bund would be placed across a narrow gorge at the lower end of the flat, and would form a lake capable of holding 70,000,000 cubic yards of water.

In the Pulney Hills Colonel Douglas Hamilton has pointed out the site of an extensive ancient lake, which might be converted into a great reservoir; and there is a project for turning the waters of the Perryaur, which now run to waste in the Cochin backwater, over the eastern side of the Travancore Hills, and thus converting Madura and Ramnad into a garden rivalling Tanjore in fertility. The damming of the Perryaur will form a lake several miles in circumference. I may add that there is a very extensive tract of mountainous country, extending from the Anamallays to near Courtallum, which is almost entirely unknown, and awaits the researches of future geographical explorers.

From a careful investigation conducted by Captain Oakes, the Engineer of the Tanjore Division, it would appear that the clearance of forests hitherto made on the hills has not yet appreciably affected the irrigation in the delta of the Cauvery. Although the floods have been higher from 1856 to 1865 than from 1846 to 1855, on the Cauvery anicut, yet, owing to the duration of the floods during the former years having far exceeded that of the floods of the latter, and owing also to the fact that the height of the water at the Cauvery anicut throughout the period from 1856 to 1865 differed but little from that from 1846 to 1855, Captain Oakes concludes that the high floods of late years are attributable rather to a greater fall of rain than to the clearance of the catchment basin. It must be remembered, however, that the destruction of forests is very far from having reached its limit, that the rapid surface-drainage caused by it already effects much mischief in the hill-districts, and that, as the felling proceeds, these consequences may eventually be felt even in the Cauvery delta.

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* From Tippoo-cardoo to the junction with the River Bowany, the Moyaar presents a singular instance of the action of a river in deepening its bed. The Moyaar ditch, as it is called, is 100 feet deep near the upper, and 800 feet at the lower end, the sides being very steep, and the land at the same level on both sides.

The construction of reservoirs in the hills is also a matter of great importance for purposes of irrigation. They will relieve the rivers of superfluous water when the floods are high, thus tending to prevent injury to the works, and furnish supplies for irrigation when the rivers are low. Every cubic foot of water which passes over an anicut into the sea, in time of floods, virtually represents so much food for the people recklessly wasted. The storage of water in reservoirs on the hills would prevent this waste, so that, while they are the obvious remedy for the evils caused by the destruction of forests, they are also essential to a thorough system of irrigation.

The deductions which I am inclined to draw from the above observations respecting the destruction of forests on the Western Ghauts are, that there will be an increase of surface-drainage likely to be very destructive to public works on the hills themselves, and eventually to be injurious to the great irrigation-works in the plains; the remedy for which evil must be sought in the storage of water by means of large reservoirs; and in the extensive planting of chinchona, teak, cork, vengay, black-wood, Australian, and other valuable trees; but that, owing to the clouds from the sea being intercepted by the mountains, there will be no sensible diminution in the actual rainfall throughout the year.

This latter remark is not intended to apply generally, for on plains and extensive plateaux the destruction of forests has certainly reduced the rainfall. Humboldt notices this result in the well-known case of the lake of Aragua in Venezuela. Sir Roderick Murchison has shown the great extent to which the mighty Volga has been lowered by the destruction of forests on the western slopes of the Ural Mountains, and by the drainage and improvement of marshy tracts. Commodore Jansen of the Dutch navy, who contributed one of the chapters to Maury's charming work, 'The Physical Geography of the Sea,' informs me of the same effects from the same causes on the island of Curaçoa. General Baker has observed these results in the country to the westward of Hissar in northern India, and Mr. Fox Wilson has given us an interesting account of the desiccation of the basin of the Orange River. The whole subject is very ably discussed by Mr. George P. Marsh, in his work on 'Physical Geography, as modified by human action.'

XII.—*On the Inland Navigation of Travancore; an Account of the Alipee Mud-bank and the Wurkallay Barrier.* By C. R. MARKHAM, Esq., F.S.A., Secretary R.G.S.

Read, January 28, 1867.

THE Malabar coast country, including Cochin and Travancore, is furnished by nature with a highway which traverses nearly its whole length. The backwaters, which form this water communication, are continuous from Trivanderum to the railroad at Ponany, except at one point; and the completion of this grand system of inland navigation, by cutting through the single barrier, is most urgently required. I had the opportunity, in my journey through Travancore, in December, 1865, of examining this barrier.

But before describing the Wurkallay Barrier, it will be useful to explain the natural causes which have given rise to the mud-bank of Alipee—a phenomenon as curious as its effects are useful. At no very distant date, geologically speaking, the sea appears to have washed the base of the ghauts. Two points ran out for a considerable distance, one of which is now represented by the Wurkallay Barrier, the other by a ridge of laterite, to the northward of Cochin. A wide bay intervened; and the well-known Hindoo tradition relates how the sea was made to recede and leave a home for the Namburi Brahmans. Without doubt alluvial deposits gradually encroached upon the sea, which were checked by the waves of the monsoon, and eventually a belt of land was formed between the backwaters and the sea, now densely covered with cocoa-nut groves. This belt forms the present sea-coast; and at one point the famous mud-bank of Alipee, the chief port of Travancore, affords safe anchorage. The whole roadstead has a remarkably soft muddy bottom; and the fluidity of the water being diminished, while its activity is deadened by the accession of mud, the anchorage is very smooth in 4 fathoms, even while the swell of the monsoon is at its height in the offing. The mud-water extends from the beach to the anchorage, a distance of about 2 miles; and it is very curious that while the mud-anchorage always remains in the same place, the line of mud-water moves up and down the coast with the anchorage as a pivot, from about a